Pros and Cons of International Weapons Procurement Collaboration

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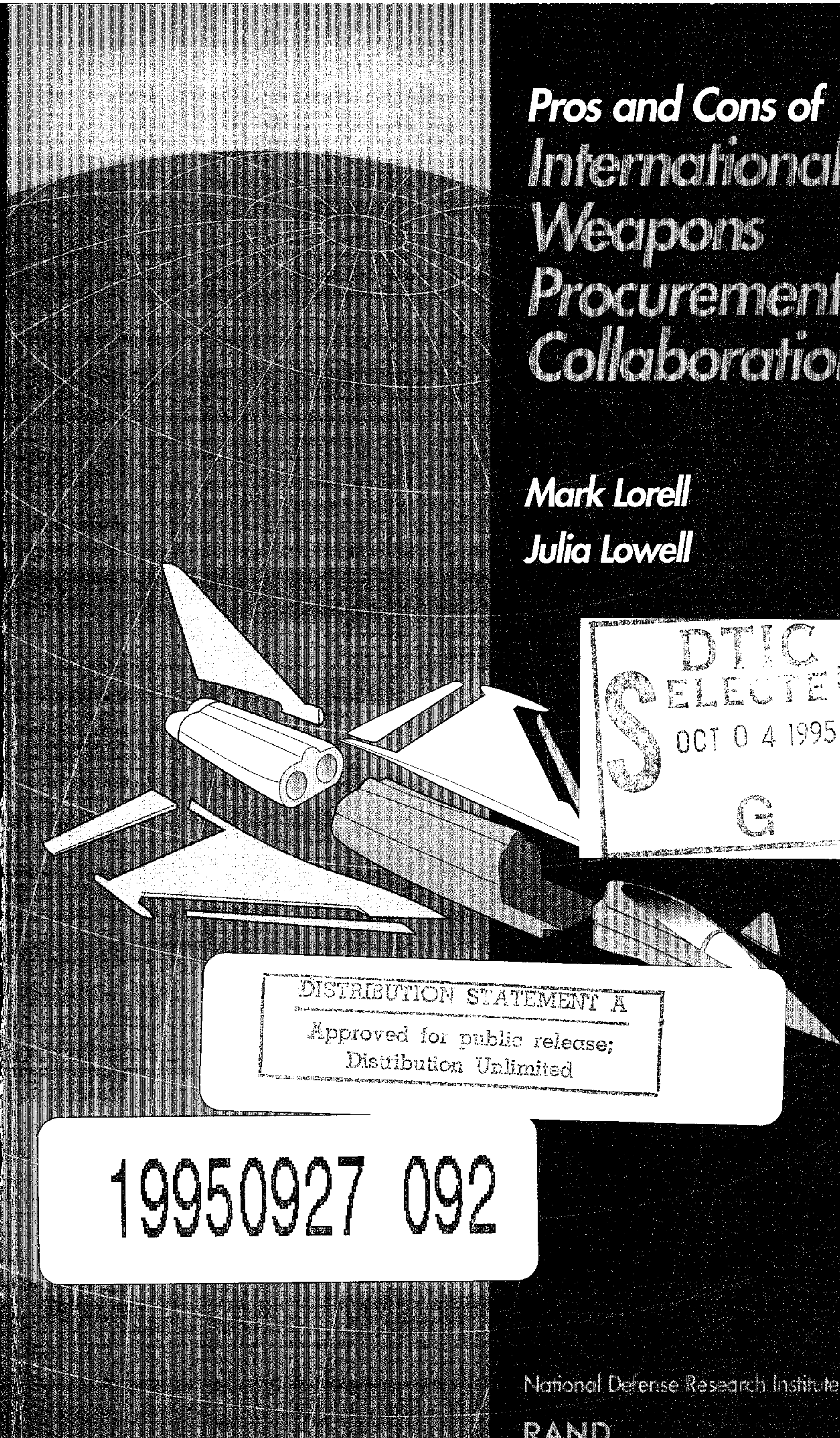

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PREFACE

This monograph presents a brief overview of the pros and cons of international collaborative weapons procurement programs, constructing a simple conceptual framework for evaluating the historical record. It draws heavily on 20 years of accumulated RAND case study research on aerospace procurement. We believe that the aerospace experience is applicable to collaborative programs for other types of military equipment. The issues addressed in the monograph, therefore, should be of interest to a broad audience including defense policy analysts, industry representatives, and policymakers.

The monograph was commissioned as a quick response for the Director, Acquisition Program Integration, Office of the Secretary of Defense, and used to support an off-site meeting for senior Department of Defense acquisition managers. The research was carried out within the Acquisition and Technology Policy Center of RAND's National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, and the defense agencies.

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SUMMARY

Over the past few years, U.S. policymakers have become increasingly interested in pursuing collaborative arrangements with our allies. Cost appears to be a major incentive: As military technologies become more complex and more expensive, even the U.S. national market is becoming too small comfortably to support the costs of developing and producing new weapons systems. By combining defense procurement with other nations, the U.S. government may be able to reduce the average cost of a given weapons system. In addition, collaborative programs offer the potential for greater operational integration of allied forces and greater political integration through shared training and doctrine.

However, substantial anecdotal evidence suggests that the predicted cost savings from collaboration rarely are achieved. This failure appears to occur primarily because few collaborative programs result in a rational division of work, economic specialization, or the elimination of R&D (research and development) redundancy. Furthermore, collaborative programs have a mixed record on the achievement of operational and political objectives such as the promotion of equipment interoperability and standardization and the promotion of alliance cohesion and support for friendly nations. One problem in the past with transatlantic programs, for example, has been the difference between U.S. and European emphases on objectives for collaboration. While the Europeans have stressed national or European-wide defense industrial base issues—acquiring technology, maintaining employment, propping up a full-spectrum defense industrial base—the United States has tended to focus on military R&D and equipment rationalization. Even within the United States, different

policymakers have pursued competing objectives for collaborative programs, making achievement of those objectives difficult.

If cost savings are of primary interest, great care must be taken in structuring programs so as to minimize inefficient duplication of tasks, incompatible national schedule and performance requirements, and excessive bureaucratic oversight. The characteristics of past programs that have succeeded at rationalizing budgets and reducing R&D and procurement costs must be identified and imitated. If greater equipment rationalization and standardization are sought, national schedule and performance requirements must be discussed and harmonized.

Political objectives may be the best reason to seek collaboration, but in such a pursuit, considerable care must be exercised to avoid embarrassing confrontations between partners: disagreements over programs that are experiencing sharp cost overruns, schedule slippage, or technical failures, or programs for which the military requirements have changed may have quite detrimental effects on international political relations.

The historical record suggests that cooperative production of U.S.–developed systems represents the lowest-risk approach to collaboration from the U.S. perspective. However, cooperative-production programs based on U.S. systems have become increasingly unacceptable to both industrialized and industrializing country partners anxious to develop and maintain their own military R&D capabilities. In the future, procurement collaboration with major U.S. allies will almost certainly require codevelopment, despite the greater potential for disagreements over program direction and management.

Over the years, RAND research on codevelopment programs has identified a variety of program characteristics that appear to promote better outcomes. These include

- genuine interest and support from a military service on each side
- limited objectives, clearly stated and agreed upon by all participants
- similar national requirements
- similar national modernization/replacement schedules

- complementary and mutually reenforcing technology, data, or R&D capabilities possessed by the R&D establishments on both sides, and a willingness to share these resources (applicable to codevelopment efforts)
- industry partners who actively seek collaboration and offer complementary technological strengths and contributions and who exhibit compatible corporate cultures
- allocation of specific work tasks to take advantage of the relative economic and technological strengths of partners
- avoidance of duplication of tasks in design, development, and production
- a single chain of command with clear lines of authority in program management on both government and industry levels.

The programs that have come the closest to achieving their participants' economic, operational, and political objectives appear to share a high proportion of these attributes. Therefore, the U.S. government would be wise to use these attributes as indicators of the likelihood of success for codevelopment programs being considered in the future. Furthermore, U.S. policymakers must think through and prioritize their own objectives before deciding what sort of collaborative defense procurement programs in which to participate.

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Chapter One

INTRODUCTION

This monograph presents an overview, illustrated by case study evidence, of the pros and cons of international collaborative weapons procurement programs. In it we develop a simple conceptual framework that allows us to identify historical lessons relevant to future U.S. policy. The examination of the historical record makes extensive use of 20 years of accumulated RAND study research on aerospace procurement. This research, while not unique, is unusual: RAND studies stand out for their use of data to measure the costs and benefits of particular collaborative programs. Several of these studies, along with other sources, are listed in a bibliography at the end of the monograph.

A good understanding of the pros and cons of collaborative weapons procurement programs is of growing importance in the current U.S. acquisition environment. Over the past few years, U.S. policymakers have become increasingly interested in pursuing collaborative arrangements with allies. Cost appears to be a major motivation: As military technologies become more complex and more expensive, even the U.S. national market is becoming too small to support the development costs of new weapons systems. By combining defense procurement with other nations, the U.S. government may be able to reduce the average cost of a given weapons system.[1] However, two

[1]A popular rule of thumb, but with no basis in empirical analysis, is that the unit cost of a weapons system increases by the square root of the number of countries participating in its development. A short discussion of the methodology and its originator can be found in Cothier and Moravcsik (1991). This method was used by the U.S. Defense Department's Inspector General in late 1992 to calculate potential cost

fundamental impediments confront policymakers who wish to make collaboration an attractive and viable procurement policy alternative for the United States.

First, most governments, including the U.S. government, are reluctant to spend domestic tax revenues on items produced in other countries. Therefore, collaborative arrangements among advanced industrialized countries often contain explicit *quid pro quos* to assure that work shares in each country are proportional to the tax revenues that each country contributes. At the same time, governments of countries that are not technologically capable of producing advanced weapons systems often demand technology transfer through collaborative production as part of their purchase agreements with more advanced weapons producers. In either case, the efficient use of resources is of second-order concern. For both advanced and less advanced economies, therefore, cost savings from collaborative as opposed to purely national programs may be insignificant.

The second major impediment to successful collaborative arrangements derives from conflicts of interest between program participants resulting from differences in operational requirements. The historical record indicates that incompatibilities in performance requirements or scheduling needs have often created "winners" and "losers" among the participating countries. As a result, in the past, countries have frequently pulled out of collaborative programs early or remained under conditions of extreme acrimony. The United States in particular has been largely unwilling to compromise on the stated operational requirements for American weapons systems.

We identify three broad classes of security objectives to identify the incentives for U.S. participation in collaborative programs and to construct a basis for judging the success or failure of such programs. For simplicity, collaboration is categorized into three general types of programs: reciprocal trade, cooperative production, and co-development.[2] A broad description of each program type is given in

savings from U.S. participation in various collaborative programs ("DoD Inspector General," 1992).

[2]The term "cooperative production" herein encompasses both licensed production and joint production arrangements, as described in Table 1.1. The terms "co-development" and "collaborative development" are used interchangeably throughout the document.

Table 1.1. Only programs that involve joint procurement agreements by two or more national governments are considered.[3] Reciprocal trade arrangements tend to be bilateral, while cooperative production and codevelopment programs are often multilateral.

Table 1.2 identifies three general categories of potential partners for the United States: first-tier industrialized countries, second-tier industrialized countries, and newly industrializing countries. The distinctions matter because the technical capabilities and experience of the partners involved are among the factors influencing the relative costs and benefits of different collaborative arrangements. The large cost overruns and schedule slippages often experienced in collaborative programs can sometimes be attributed directly to the inexperience of contractors from second-tier and newly industrializing partner countries (Rich et al., 1981, p. 101).[4] Of course, purely national programs within first-tier countries are also vulnerable to risks associated with the development of new technologies, but the scarcity of experienced contractors in second- and third-tier countries may increase the risks associated with production of known designs.

In the following chapter, the theoretical benefits of international collaboration in weapons procurement are described in terms of general sets of security objectives. We briefly discuss how European and U.S. government objectives have evolved over time. In the third chapter, these government objectives provide a context for our examination of the historical record on collaboration. We form general conclusions about the efficacy of collaborative programs and illustrated them with short case studies of early as well as more recent European and transatlantic experiences. Because of the limited nature of the empirical evidence, we draw heavily from previous re-

[3]Private market arrangements between different national prime contractors or between prime contractors and subcontractors from different countries are not considered here because these private contract arrangements do not tend to suffer from the same types of problems as government-initiated collaborations.

[4]For example, during the course of the F-16 cooperative production program involving the United States, Belgium, Denmark, the Netherlands, and Norway, the inexperienced Danish firm producing the U.S.-designed engine gearbox failed to meet its cost and delivery responsibilities. One of the U.S. partners was forced to take over production of the gearbox to keep assembly lines on schedule.

Table 1.1

Three Types of Collaborative Programs

Program Type	Description
Reciprocal trade: "Two Way Street" and "Family of Weapons"	Each government agrees to purchase weapons or weapons systems developed and produced by defense contractors in the partner country. "Two Way Street" approach encourages the evolution of a balanced transatlantic arms trade. Under "Family of Weapons" concept, the partner countries each develop and produce complementary weapons systems. Examples: AMRAAM/ASRAAM[a] (GE, UK, US)
Cooperative production: licensed production or joint production	Defense contractors from two or more partner countries produce weapons systems developed by firms from one of the partner countries. Under joint production, original developer produces system with its foreign partners. Participating governments reconcile acquisition schedules. Production shares usually proportional to tax revenues contributed. Transfers of militarily sensitive technologies and third-party sales must be approved by the home government of the original developer. Examples: F-104 (BE, CA, GE, IT, JA, NL, US) F-16 (BE, DK, NL, NO, US)
Codevelopment	Defense contractors from partner countries jointly develop and produce weapons systems; marketing and after-sales servicing of the systems may or may not be joint. Participating governments reconcile military requirements as well as acquisition schedules to a greater extent than under cooperative production. As under cooperative production, both R&D and production shares chosen according to relative tax shares rather than economic efficiency criteria. Examples: Jaguar (FR, UK) X-31 (GE, US)

NOTE: BE=Belgium, CA=Canada; DK=Denmark, FR=France, GE=Germany, IT=Italy, JA=Japan, NL=Netherlands, NO=Norway, UK=United Kingdom, US=United States.

[a]Advanced medium range air-to-air missile/advanced short range air-to-air missile.

search on aerospace procurement. However, we believe that our aerospace case studies are applicable to collaborative procurement programs for other types of military equipment. In the final chapter, we sum up the lessons learned and the implications of our findings for U.S. policymakers.

Table 1.2

Potential Collaboration Partners for the United States

Potential Partners	Description
First-tier industrialized countries	Relatively large and experienced defense sectors with indigenous technologies of interest to the United States. Able to absorb U.S. technologies relatively easily. Often uninterested in cooperative production because of desire to maintain competitive domestic R&D capabilities. Examples: France, Germany, United Kingdom
Second-tier industrialized countries	Smaller and less experienced defense sectors. Narrow spectrum of development and production capabilities limits partnership in full weapons system development, but able to participate in cooperative production arrangements. Produce sophisticated, indigenously developed subsystems and components. Examples: Belgium, Netherlands, Norway
Newly industrializing countries	Small and relatively inexperienced defense sectors. Narrow spectrum of development and production capabilities limits partnership in full weapons system development, but able to participate in cooperative production arrangements. Currently unable to produce indigenously developed subsystems that meet U.S. military performance requirements, but learning rapidly. Can produce sophisticated components. Examples: Brazil, S. Korea, Turkey

Chapter Two

PRINCIPAL OBJECTIVES AND THEORETICAL BENEFITS

Advocates of international weapons collaboration have long argued that numerous security benefits should flow from joint R&D and production programs. These benefits may be grouped into the following three broad categories of objectives:

- **Economic**—rationalization of alliance R&D budgets and resources and reduction of R&D and procurement costs for individual partners.
- **Operational**—promotion of equipment interoperability and standardization.[1]
- **Political**—promotion of alliance cohesion and support for friendly nations.

A brief summary of the pros and cons of each type of collaborative program, grouped according to these three broad categories, is presented in Table 2.1.

Economically, all three types of collaborative procurement arrangements are likely to increase the size of the market for a given weapons system. Defense contractors can therefore pass on any economies of scale to their government clients, who in turn can make defense budgets stretch further. In theory, all three forms of collaboration should also entail significantly lower costs than do na-

[1]Standardized weapons are identical or nearly identical. Interoperable weapon systems may differ substantially, but they can use the same consumables such as fuel and ammunition.

Table 2.1

Pros and Cons of Collaborative Programs

	Type of Program		
Objective	Reciprocal Trade	Cooperative Production[a]	Codevelopment
Economic	**Pro:** Specialization by U.S. and partners increases size of market and reduces costs.	**Pro:** Specialization of production, larger market reduce costs while U.S. still able to maintain R&D and some production capability.	**Pro:** Shared costs of R&D and production, larger market reduce costs, allowing U.S. to maintain wider range of R&D and production capabilities.
	Con: U.S. loses R&D and production capabilities for weapons outside area of specialization.	**Con:** Duplication of production, small size, and inexperience of partners raise costs for U.S.	**Con:** Unintentional transfer of technology may harm more advanced U.S. industry. Greater risk of cost growth and schedule slippage.
Operational	**Pro:** U.S. and partners share common equipment.	**Pro:** U.S. and partners share common equipment.	**Pro:** U.S. and partners share common equipment.
	Con: U.S. requirements compromised; independent U.S. capability diminished.	**Con:** Significant differences between models produced by partners.	**Con:** U.S. requirements compromised; independent U.S. capability diminished. Significant differences between models produced by partners.
Political	**Pro:** Partners strengthen political ties through military reliance. Common equipment encourages shared training and doctrine.	**Pro:** U.S. able to influence partners' defense postures. Common equipment encourages shared training and doctrine.	**Pro:** Better than partners developing independent R&D capability. Common equipment encourages shared training and doctrine.
	Con: Compromised requirements, loss of independent capability strain political ties.	**Con:** Disagreements over program management strain political ties.	**Con:** Compromised requirements, disagreements over program management strain political ties.

[a]Assumes licenser is United States.

tional programs, because of increased international specialization of design, development, and production. However, complete international specialization also may mean partners lose R&D or production capabilities for systems or technologies outside their area of specialization. Incomplete specialization may mean expensive duplication of R&D or production work tasks, as well as unintentional transfers of technology to foreign competitors.

Operationally, it has generally been believed that the adoption of standard, or at least interoperable, equipment by allied countries enhances their joint warfighting capabilities.[2] In theory, reciprocal trade, cooperative production, and codevelopment programs all result in the sharing of common equipment designs for weapons systems. In practice, as illustrated below, collaborative programs may compromise national performance requirements without contributing to either the standardization or interoperability of allied equipment.

Collaborative weapons procurement arrangements may also strengthen political ties among allies through shared training and doctrine. Another possible outcome, although less often stated by advocates of collaboration, is that politically dominant nations may use collaborative programs to influence the defense capabilities and strategies of weaker partners. However, compromises over national requirements and disagreements over program leadership and management may in fact strain political relations between partners.

In the past, at least at the rhetorical level, the United States tended to emphasize the operational and political dimensions of collaborative weapons procurement programs. For example, the "Guidelines for Japan–U.S. Defense Cooperation," originally negotiated in 1978, focused on the promotion of greater joint defense planning and training for combat operations, intelligence, and logistics (Japan Defense Agency, 1990). But in recent years, the United States has begun to advocate weapons procurement collaboration in NATO primarily as a means of rationalizing limited national R&D budgets. In so doing,

[2]An opposing school of thought argues that standardization of allied equipment is *not* militarily desirable: An enemy may find a counter to one particular weapon, yet be prevented from effectively countering a diversity of equipment with similar roles (Webb, 1989, p.26).

U.S. policymakers hope to gain a more effective overall force structure with less money—literally, "more bang for the buck." The goal of alliance-wide R&D rationalization and defense burden-sharing with our allies has increased in importance with the tightening of federal defense budgets in the 1980s and 1990s. In the 1990s security environment, the growing complexity of military technologies is driving the development costs of new weapons systems too high even for the U.S. national market comfortably to support.

Congressional legislation has reflected this trend. For example, the Culver-Nunn (1977), Roth-Glenn-Nunn (1982), and Nunn-Warner (1986) amendments each encouraged defense cooperation with NATO allies through collaborative procurement of military equipment (Kaganoff, 1992). The first two amendments focused on operational objectives, whereas the Nunn-Warner amendment stressed military/economic objectives—and particularly the joint development of advanced military technologies. More recently, as part of the fiscal year 1990–1991 Defense Authorization Act, the Defense Department was asked to make an annual report to Congress on the "status, funding, and schedule of cooperative research programs . . . underway or proposed with both our NATO and major non-NATO allies" (Kaganoff, 1993, p. 12). Congress' request was made at least in part to emphasize its interest in rationalizing defense budgets through collaboration. In 1993, Secretary of Defense Perry's first speech after taking office included a vow to "resurrect" international cooperative programs in order to stretch resources further in an era of declining budgets ("Perry Vows to 'Resurrect'," 1993, p. 29).

In Europe, however, economic and political motives for collaboration have always tended to dominate operational objectives. Furthermore, the most important economic motivation driving European collaborative programs has not tended to be rationalization of joint budgetary and R&D resources. The economic motivations driving the early European initiators of collaborative programs were primarily based on maintaining a comprehensive national defense industrial base in the face of rising R&D and procurement costs.

Collaboration received its greatest impetus beginning in the 1950s when the first-tier European members of NATO—France, Germany, and the United Kingdom—could no longer afford to develop a full

spectrum of modern weapon systems on a purely national basis. For example, Germany used early Franco-German collaborative arrangements to increase the overall capabilities of its defense industrial base. By linking its defense industry to that of France, Germany acquired both technology and R&D experience. Collaboration was also seen as a means to advance a variety of international political objectives.[3] For example, the early Franco-German programs helped to bind German military procurement to France (Kohl, 1971). However, these programs generally did not avoid duplication of R&D or production and therefore did not lead to a more rational allocation of joint resources and work tasks.

Later, the leading European arms developers began seeking greater European-wide consolidation as a means of countering American competition. The Independent European Program Group (IEPG), which is not part of NATO, was created in 1976 to provide an all-European alternative to dependence on the United States for defense procurement.[4] After a slow start, in 1985, the Europeans chose the IEPG as the "main multilateral forum for European defense procurement collaboration" (Webb, 1988, p. 103). A major report commissioned by the IEPG in 1988 stressed ways to improve the position of European defense firms relative to their U.S. competitors.

Thus, one problem in the past with transatlantic collaborative programs has been the difference between U.S. and European emphases on objectives for collaboration. While the European programs stressed national or European-wide defense industrial base issues—acquiring technology, maintaining employment, propping up a full-spectrum defense industrial base—the U.S. programs focused on military R&D and equipment rationalization.[5] Even within the United States, however, different sets of policymakers have often promoted alternative objectives, creating problems for collaborative programs. For example, individual U.S. government agencies have

[3]Nau (1974) argues that political considerations were dominant.

[4]The IEPG comprises all European members of NATO including France but excluding Iceland.

[5]Correctly or not, Europeans often viewed the U.S. promotion of "RSI" (rationalization, standardization, and interoperability) as a thinly disguised strategy of promoting the sales, licensed production, or cooperative modification of U.S. weapons systems.

pushed conflicting agendas in the U.S.–Japanese codevelopment of the FS-X fighter, contributing to cost overruns and creating tensions in the U.S.–Japanese security relationship.[6]

As a result of these differing objectives and a variety of other problems, the record of past collaboration programs remains mixed. In the next section we provide an overview of that record.

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[6]In ongoing RAND research, Lorell examines how the U.S. Departments of State and Defense supported the FS-X program largely for operational and political reasons—wishing to promote interoperability with the Japanese Self-Defense Forces and to discourage a more autonomous Japanese defense posture. On the other hand, Congress and the Department of Commerce both tended to oppose FS-X on the economic grounds that the transfer of U.S. technology through the program would harm the U.S. aerospace industry's long-term competitiveness. The resulting disputes over technology transfers contributed to cost overruns, while the hot-and-cold U.S. attitude toward FS-X greatly frustrated the Japanese.

Chapter Three

THE RECORD

As described above, there are three distinct security policy dimensions to the stated U.S. incentives for participation in international collaborative weapons procurement programs: economic, operational, and political. The historical record on collaboration, therefore, must be evaluated along each of these dimensions. It is possible for a program to succeed on one dimension yet fail on another, but it is perhaps more likely that success breeds success and failure breeds failure on all dimensions at once. In considering the cases discussed below, therefore, possible overlaps as well as conflicts between objectives should be kept in mind. For example, a codevelopment program that appears expensive relative to purely national alternatives may put stress on the political relations of the partners involved. Similarly, if a cooperative-production program results in significantly standardized equipment across partners, it is also more likely to have achieved alliance-wide cost-reduction through specialization of production.

This section presents evidence regarding past collaborative-program experience.[1] We demonstrate that the differences between the expected or theoretical economic, operational, and political benefits of programs and actual program outcomes most often result from two types of conflicts between participants: (1) conflicts over operational requirements and (2) conflicts over national workshares in weapons system design, development, and production.

[1]A listing of selected collaborative aerospace programs referenced in the text is given in the Appendix, Table A.1.

ECONOMIC RECORD

Despite more than forty years of extensive experience with collaboration—primarily in Europe—far too little hard evidence is publicly available to judge the cost effectiveness of major collaboration programs relative to national programs. This is particularly the case for intra-European codevelopment programs. Estimating the development and production costs of national programs is difficult, but even greater informational constraints characterize international collaboration programs. The participants in major European collaboration programs, for example, often do not really know the expenditures of their partners—and therefore cannot even determine the total cost of the program.

However, there is substantial anecdotal evidence that suggests that the cost savings theoretically predicted to result from collaboration rarely are achieved. This failure to save costs appears to occur primarily because few collaborative programs achieve a rational division of work, economic specialization, or the elimination of R&D redundancy. Typically, participating governments seek work in areas in which their national industries have little experience. They wish to acquire new technologies and production capabilities rather than build on existing national comparative advantage. For example, in the Anglo-German-Italian Tornado collaborative fighter development program, the German government insisted that German firms develop the fuselage center section with its sophisticated and challenging "swing-wing" mechanism. German industry had less experience and capability than British industry in the technical areas necessary to develop this part of the aircraft. It was precisely for this reason that German industry insisted on receiving this part of the work, so that it could learn and develop the necessary expertise through the program.

Failures to specialize also abound. In the Eurofighter-2000 program, for example, the development of every important subsystem and component involves industry representatives from each of the four participating countries (Britain, Germany, Italy, and Spain). Historically, most collaborative development programs have had assembly lines in each of the participating countries during the pro-

duction phase. Examples include Transall (France, Germany), Jaguar (Britain, France), FS-X (Japan, United States), and Tornado.[2] A collaborative program that *has* allocated work in a more rational manner is the German-American X-31 program. Two of these programs will be discussed in greater detail below.

The desire to obtain new skills and technologies through collaborative programs, in addition to the failure to specialize, can thwart economically efficient work allocation. Inexperienced contractors must undergo steep learning curves. Multiple assembly lines and R&D overlaps can cause process inefficiencies and create bloated administrative bureaucracies. The result can be significant cost growth and schedule slippage. On the other hand, in contrast to national programs, multinational participation could theoretically lead to more stable funding, which in turn could substantially *curb* cost growth and schedule slippage. Advocates of collaboration argue that this point is particularly relevant for the United States, where program appropriations occur on an annual as opposed to a multiyear basis. However, there appears to be little evidence that collaborative arrangements have contributed significantly to program stability in the past.[3]

Very little hard evidence is available on the economic trade-offs between national and collaborative programs. RAND researchers (Rich et al., 1981) developed a framework that allowed them to assess the influence of collaboration on program length and schedule slippage. Using data from six different European collaborative aircraft development projects, they formed a rudimentary characterization of the level of collaboration on each project. They then estimated the sensitivity of program length and schedule slippage to the level of

[2]In the F-SX program, the wing box for the prototype is being jointly produced in the United States and Japan. National production shares for the full production phase have not yet been determined.

[3]The record is mixed: In some cases, national governments have stuck to their commitments despite unhappiness with a program (for example, France in the case of the Anglo-French Jaguar codevelopment program), while in other cases they have simply opted out of the agreement (for example, Germany and possibly the United States in the case of the AMRAAM/ASRAAM reciprocal trade agreement). See, for example, "Cooperate on Projects" (1993). Rich et al. (1981, p. 120) argue that the multinational character of the F-16 cooperative production program minimized costly schedule changes.

collaboration. Rich et al. found that the multinational programs involving more extensive collaboration tended to last longer. However, contrasts between the magnitude or pattern of slippage in European national versus collaborative programs were not particularly large.

In a second set of estimations concerning cost growth, Rich et al. used data from U.S. licensed production of the Franco-German Roland missile to conclude that transfer of designs, which in theory should lower development costs, does not necessarily minimize overall program cost growth. With Roland, U.S. contractors significantly underestimated the technology transfer task and overestimated the mutuality of U.S. and European operational requirements. Estimated program cost growth exceeded 200 percent, well over the average for U.S. national missile programs of the 1970s.

Of course, although these cost-growth comparisons do suggest that greater risks are associated with collaborative relative to national programs, they do not necessarily imply that collaboration entails greater total program costs. In fact, in a further attempt to quantify the importance of selected common features of collaborative programs, Rich et al. found that the duplication of tasks often characteristic of collaborative programs does not have to imply greater costs. For the U.S. B-52 bomber and F-100 fighter programs, which both featured duplication of production and assembly, in each case lower overhead rates at the second production facility and coordination of materials purchasing actually resulted in cost savings. Overall, the Rich et al. examination of the B-52 and F-100 programs indicates that cooperative-production programs need not fail on economic grounds, but the evidence from Roland is not encouraging.

Collaborative programs probably do cost each partner less on average than purely national programs, but the empirical evidence on the cost effectiveness of collaboration is weak and not always consistent. For example, total costs incurred under the Anglo-French Jaguar codevelopment program appear to have been much greater for each partner than under the French national program to develop the Mirage F-1, an arguably more technically complex aircraft. In any case, the apparent failure of many if not most collaborative programs—particularly codevelopment efforts—to achieve large cost savings raises serious questions about their utility, since they generally require other sacrifices to be made by the participants.

Two short case studies below illustrate this point. The first compares the cost growth in early French collaborative development programs to purely national French programs. Although not recent, the French experience provides a rough data-based comparison of national and collaborative programs, and supports arguments that early European experiments with codevelopment were in the main politically motivated. The second case study is an examination of cost and schedule developments in the U.S.-designed and European license-produced F-16 program. Both examples are based on research on international weapons procurement collaboration conducted at RAND over the past 20 years.

Case Study 1: Cost Growth in French Tactical Aircraft Programs[4]

Funds dedicated to aircraft codevelopment projects have historically amounted to a relatively small percentage of total military aerospace R&D and equipment outlays, even for the originator of European codevelopment, France. For example, between 1965 and 1970, codevelopment-program authorizations accounted for less than 17 percent of total French military aircraft R&D and procurement authorizations (about 2 percent of the total projected French military budget). However, the funds actually expended on codevelopment programs during this period made up a larger percentage of total aircraft expenditures than the original authorizations. By 1970, codevelopment programs may have reached as much as one-third of total aircraft equipment expenditures. This result is primarily because the cost overruns on codevelopment projects were greater than those experienced on almost all national programs.

Between 1965 and 1970, cost overruns for national programs ranged from –3.1 percent for a battlefield surveillance drone to 33.1 percent for the Mirage III project. Collaborative-program results are shown in Table 3.1.

[4]From unpublished 1980 research by Lorell. All figures are based on data from French parliamentary publications and from Carlier (1979), Kohl (1971), and Pinatel (1976).

Table 3.1

Cost Growth in French Codevelopment Efforts (1965–1970)

Program	Cost Growth (%)
Atlantic	+ 17.2
Alpha Jet[a]	+ 37.0
Transall	+ 37.4
Jaguar	+309.2

[a]All expenditures may not have been on collaborative projects.

The cost growth alone on the Jaguar program for France surpassed the total program costs of every other French tactical aircraft project and equaled nearly two and one-half times the total costs for the national Mirage F-1 program during the period. By 1972, the Jaguar airframe had experienced a 600 percent cost overrun and the engine, a 300 percent cost overrun.[5]

Although few published data are available, the anecdotal evidence indicates that Jaguar was not unique among European collaborative programs of the 1960s and early 1970s. Once under way, French codevelopment programs in particular seriously disrupted other national projects because of their huge cost overruns. Yet, during this period, all of their military aircraft codevelopment projects were relatively low-technology efforts (conventional transports, patrol aircraft, trainers, helicopters, tactical missiles, etc.). All French high-technology and high-military-priority projects were developed on a purely national basis. That cost-savings and budget constraints may not have been a key motivating consideration in the initiation of codevelopment projects seems to be confirmed by the admission of French officials that detailed cost studies were conducted neither before nor after most codevelopment projects.

But the early French experience with codevelopment programs may not be a reliable guide to the economic costs and benefits of various collaborative arrangements considered by the United States. First, the high cost growth experienced by French codevelopment programs may have sprung from an inattention to cost factors that re-

[5]More details of the Jaguar program are described in Case Study 3 below.

sulted in unrealistic initial estimates of total program costs. All programs involving the development of new weapons systems are more susceptible than pure production programs to cost overruns because of technical risks. Second, political considerations may have caused the French to choose high-cost partners with incompatible weapons system requirements. The United States may have more flexibility in choosing partners for specific projects.

In contrast to the French experience with codevelopment, Hall and Johnson (1968, pp. 73–76) argue that the total cost of a Japanese F-104J produced under license from Lockheed was actually less than the cost of a finished airplane produced in the United States. In Japan, high prices for materials were more than offset by low wages.[6] In addition, as illustrated below, the record on U.S.-licensed production of the F-16 fighter indicates that, where program leadership is unambiguous and requirements well-established, collaborative programs need not fail on economic grounds. But even for the United States, the economic outlook for codevelopment is not encouraging: In the U.S.–Japanese FS-X fighter codevelopment program, for example, difficulties and disagreements during the development phase are estimated to have resulted in cost growth of over 100 percent.[7]

Case Study 2: Working Together on the F-16[8]

The F-16 program remains one of the most ambitious cooperative-production efforts ever attempted. It arose largely as a coincidence of wants: At roughly the same time that the U.S. Air Force decided to initiate a lightweight fighter program, four NATO nations (Belgium, Denmark, the Netherlands, and Norway) formed a consortium to replace their aging F-104s. After aggressive marketing and promo-

[6]According to Hall and Johnson, even with license fees a Japanese-built F-104J cost approximately 90 percent of a U.S.-built F-104G. As pointed out below, however, the F-104G and the F-104J are not strictly comparable aircraft.

[7]In the FS-X case, Japanese officials blamed U.S. unwillingness to transfer F-16 flight control computer source codes and other technologies for the considerable cost growth experienced in the program. American officials, on the other hand, claimed that extensive Japanese modifications to the original F-16 design were largely responsible for cost overruns. (Lorell, ongoing RAND research.)

[8]From Rich et al., 1981, pp. 79–123.

tion by French, Swedish, and American contenders for their business, the four European Production Group (EPG) members chose the American F-16. The cooperative production arrangement was considered to be one of its strongest selling points.

Under the agreement, contractors from the four EPG nations plus the United States concurrently produced the airframe, engine, and avionics with assembly lines in all five countries. Final assembly of the aircraft took place in three countries: Belgium, the Netherlands, and the United States. Despite these complications, the aircraft were delivered and deployed largely on time, and the program engendered considerable third-party sales. In addition, neither program cost growth nor total program cost was remarkable. Although some cost growth occurred, the F-16 program experienced far less than did many other major national programs. Table 3.2 shows estimated cost growth in the F-16 program as of 1980.

For the U.S. Air Force, participation in cooperative production of the F-16 added approximately 5 percent to the total cost of the first 650 USAF F-16s produced. Economies of scale obtained by increasing production volumes were slightly more than offset by the increased costs associated with incorporation of European-produced items. However, R&D recoupment charges paid directly into the U.S. Treasury by the European participants probably eliminated any overall cost penalty suffered by the United States.

With respect to economic objectives, therefore, the F-16 program shows that collaborative programs can be moderately successful.

Table 3.2

Estimated Cost Growth in the F-16 Multinational Program (through 1980)

Phase	No. of Aircraft	Baseline Cost (1975 $ millions)	Est. Cost Growth (percent)
Development	8	578.6	+28.3
Procurement	650	3,798.2	+13.3
Total program	658	4,376.8	+15.3

However, there are several characteristics of the F-16 program that make it unlikely to be repeated:

- The F-16 program was unusual in that the schedule and performance requirements for all five of the participants were quite similar. The EPG nations had a common inventory of aging F-104s that needed replacement; the U.S. Air Force was able to compromise on its slightly different scheduling needs. Some shortcuts were taken in the form of concurrent development and production, but they worked. Costly schedule changes were for the most part avoided.
- The maintenance of an indigenous U.S. production capability for the complete system minimized serious schedule slippage caused by European production difficulties. The reservoir of U.S. production support overcame lags in European deliveries of key airframe, engine, and avionics components.
- The F-16 was a U.S.-designed and -developed aircraft, and largely a U.S.-managed program. The technology was well-known, and the program leadership was unambiguous. The transfer of technology was overseen by the U.S. contractor, who was available to work out difficulties associated with overseas production.

These factors together seem unlikely to reoccur. Few countries still share large common weapons systems inventories, making it increasingly difficult to reconcile military procurement requirements. And while U.S. contractors may well have excess productive capacity to smooth over production gaps, simple cooperative production programs with unambiguous U.S. leadership are no longer in favor with most of our first- and second-tier allies. In the future, collaborative programs with such allies will undoubtedly require cooperative development as well as production.

In sum, the evidence on the cost growth and cost savings associated with cooperative production programs is mixed. The F-104J, B-52, and F-100 examples indicate that duplication of production may actually lower total program costs when there are lower wages or overhead rates at the second production facility. In the case of the F-16,

it is estimated that collaboration had little effect on overall program costs to the U.S. Air Force. In the Roland example, however, despite the transfer of existing designs, estimated program cost growth was well over the average for comparable U.S. national missile programs. The economic record on codevelopment programs, although sketchy, is far less positive: multinational collaboration appears to add to the uncertainty of developing new weapons systems, contributing significantly to program cost growth. The Jaguar case, the U.S.-Japan FS-X program, and considerable anecdotal evidence all suggest that achieving the full economic benefits theoretically available on codevelopment programs is rare.

OPERATIONAL RECORD

The stated military objectives of most collaborative defense acquisition agreements were defined in the context of the Cold War. These objectives were to enhance logistical efficiency, doctrinal compatibility, and wartime support capabilities through the promotion of standardization and interoperability of military equipment. However, interoperability does not require the standardization of equipment or equipment procurement collaboration, and collaboration doesn't necessarily result in either interoperability or standardization. This is particularly true for codevelopment programs, but it can also be the case in cooperative production programs as illustrated in the first case study below.

NATO has had some success since the late 1970s in reducing the number of competing new designs for military equipment. Nevertheless, no significant increase in the standardization and interoperability of NATO equipment has occurred. Two factors are responsible: (1) the increasing age of inventories has raised the number of types of equipment deployed, and (2) the average number of countries acquiring each new design has fallen. The second factor is "associated with the emergence of collaborative developments which appear to have bound the participating countries into purchasing designs that have not generally proved attractive to others" (Webb, 1989, p. 26). As a result, the number of types of fighter aircraft increased from 15 in the late 1960s to 22 in 1988; the number of types of main battle tanks increased from 7 in the 1960s and 1970s to 10 in

the 1980s; and the number of types of naval surface-to-air missiles increased from 7 in the 1960s to 12 by the late 1970s.

The case studies presented below illustrate two points about the achievement of operational objectives through collaboration in military equipment procurement. First, the historical record on licensing the F-104 fighter shows that even cooperative production programs that start from the same baseline-developed weapons system do not necessarily result in standardized equipment. Second, the case of the SEPECAT Jaguar shows that codevelopment can result in national versions of a "common" weapons system that vastly differ in their function and capabilities.[9] In sum, to the extent that national defense establishments perceive differing operational requirements from those of their allies, the goals of standardization and interoperability are unlikely to be achieved. If they are achieved, it is likely to be at the expense of the partner with the least political or technical punch.

Case Study 3: All Coproduced Aircraft Are Not Created Equal

The United States Air Force (USAF) Air Defense Command bought a small number of the Lockheed F-104A Starfighter and other similar versions in the mid to late 1950s. These early USAF aircraft were mostly lightweight, daytime-fighter/interceptors for air defense against enemy bombers and were never widely deployed within the United States.[10] The F-104A, for example, did not have an all-weather operational capability and had limited range. After just two years the USAF's F-104As were withdrawn from the active combat list. Many were later reissued to the Air National Guard (Reed, 1981).

In 1958, however, Lockheed introduced a completely redesigned version of the F-104, called the F-104G, which was created to meet the European and particularly West German need for a super-

[9]SEPECAT is the acronym for the Societe Européenne de Production de L'Avion, Ecole Combat et Appui Tactique, a consortium formed between British Aerospace and Breguet Aviation in 1966. Breguet later merged with Avions Marcel Dassault (Dassault). (*Jane's All the World's Aircraft*, 1982–1983.)

[10]The versions bought by the USAF were the F-104A, F-104B, F-104C, and F-104D. The C and D versions were fighter/bombers. (*Jane's*, 1968.)

sonic fighter/bomber.[11] The F-104G was an attack/strike bomber that had an extensively modified airframe, a more sophisticated radar system, an inertial navigation system, maneuvering flaps, and many other features that differed from the USAF versions. Three different European consortiums were licensed to produce a total of 977 F-104Gs, with participation by firms from Germany, the Netherlands, Belgium, and Italy (*Jane's*, 1968). The Royal Canadian Air Force ordered a slightly different version of the F-104G, the CF-104, which was a strike-reconnaissance aircraft produced under license in Canada.[12] A Japanese version, the F-104J, had a similar airframe to the F-104G but a different engine and different armaments.

In the late 1960s, the last and most sophisticated version of the F-104 was produced under license by Aeritalia of Italy. The F-104S was an all-weather interceptor aircraft with a moving-target indication and tracking radar, electronic countermeasures, and improved air-to-air missile capabilities. In sharp contrast to the short production history of the early F-104A, production of the F-104S continued for more than 10 years. The Italian Air Force's F-104Ss began to be replaced only after the arrival of the Tornado fighter in the mid-1980s (Reed, 1981).

The F-104 Starfighter was the centerpiece of aerial self-defense for many if not most of the United States' NATO and non-NATO allies throughout the decade of the 1960s. According to Reed (1981, p. 40), the original West German purchase order was followed by other NATO allies, "in the interests of standardization and convenience." Yet Reed also acknowledges that the allies' air forces "introduced a bewildering variety of modifications to match the uses to which their squadrons put them" (Reed, 1981, p. 88). Not all Starfighters were created equal. Furthermore, in the United States, the Starfighter was never able to replace the F-106, which dominated U.S. air self-

[11]A representative of one of Lockheed's European competitors at the time suggests that Lockheed was very anxious to sell the F-104 in Europe because the USAF had "cancelled all but a few hundred of its own build, leaving a production situation ripe for offering to the world." (Reed, 1981, p. 40.)

[12]Under the Mutual Assistance Program, the Canadians also built some F-104Gs which they sold to Denmark, Norway, Greece, and Turkey. (Reed, 1981.)

defense during much of the period, and it is unlikely that in a European war U.S. forces would have used F-104s.[13]

Outcomes such as these are not uncommon for other licensed production programs. For example, when U.S. industry agreed to license-produce the British-developed Canberra in the 1950s—the first time the U.S. services had procured a foreign-designed fighter or bomber since 1918—the aircraft was extensively modified into the B-57. Similar problems arose from the U.S. effort to produce the Franco-German Roland air-defense missile system and the advanced British Harrier VSTOL fighter under license.[14] Simply put, collaborative weapons-procurement programs, even those involving licensed production, do not automatically lead to standardized equipment. The next case study suggests that the same result can also be true for codevelopment programs.

Case Study 4: Some Codeveloped Aircraft Are More Equal Than Others

The SEPECAT Jaguar was an Anglo-French codevelopment of a strike fighter/trainer in the mid to late 1960s. In 1965, the British and French air forces established common requirements for a dual-role aircraft to be used as an advanced and operational trainer and a tactical support aircraft (*Jane's*, 1981–1982). However, the French air force wanted an advanced trainer with some attack capability, while the British wanted an attack aircraft that could be used for training. The British view prevailed, so that the codeveloped airframe/engine combination was more capable—and thus considerably more expensive—than originally desired or intended by the French.

In the end, each partner fulfilled its own operational requirements through procurement of unique national avionics, subsystems, and other equipment, making the British Jaguar much more capable (and expensive) than the French. The simple French Jaguar A had a twin gyroscope navigation system, basic Doppler range radar, and a basic navigational computer. The Royal Air Force Jaguar GR-1 had digital

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[13]See for example, the statement by Kelly Johnson, designer of the F-104, in Reed, 1981, p.13.

[14]VSTOL is the acronym for Very Short Takeoff and Landing.

inertial navigation, head-up display, projected map display, an integrated navigation/attack system, a laser range finder, electronic countermeasures, and other sophisticated features. In the 1980s, the French began upgrading their Jaguars but again chose equipment different from that used by the British. An export version, the Jaguar International, is similar to the British GR-1 but has a more powerful engine (*Jane's* 1981–1982).

Thus, although the Jaguar program resulted in a common airframe and engines combination, the major avionics, subsystems, and other equipment on the French and British versions differed considerably. Furthermore, the French were forced to procure an aircraft that did not meet their original requirements for a low-cost advanced trainer with secondary attack capabilities. France went on to meet those requirements in the late 1960s by launching with Germany a new collaborative program, the Alpha Jet, in which the cycle of incompatibility was once again repeated.[15] Like the Royal Air Force, the German Luftwaffe wanted more attack capability than that desired by France's Armée de l'Air, but this time, French interests dominated the program. In the Alpha Jet, the Germans ended up with a very modest attack aircraft that fell far below their original expectations.

The F-104 and Jaguar case studies reveal that collaborative programs may fail to meet operational objectives in two different ways. First, collaborative programs may fail to achieve equipment standardization or even interoperability between the partners. This is documented by the F-104 cooperative-production program experience. Second, one or more partners' individual performance requirements may be compromised. In the case of the Jaguar codevelopment program, collaboration failed on both accounts: The French and British air forces did not standardize their equipment, yet the French version of the aircraft still did not meet French performance requirements.[16]

Other case studies teach the same lesson. For example, the Franco-German codevelopment of the Transall in the early 1960s obliged the

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[15]The Alpha Jet partnership consisted of France's Dassault and Germany's Messerschmidt-Bolkow-Blohm.

[16]In 1973 General Paul Stehlin, former French air force chief of staff, labeled the Jaguar "Our most costly and ill-conceived aircraft." (Carlier, 1979, p. 148.)

Germans to procure a long-range large-capacity military transport whose capabilities far exceeded those required by the Luftwaffe (Lorell, 1980).[17] Instead, the Transall met French requirements for a strategic lifter optimized for conditions in North Africa. The Germans also were forced to compromise their requirements on the Anglo-German-Italian Tornado codevelopment program, which was dominated by the British need for a long-range strike/attack fighter rather than the lighter and more maneuverable air-defense fighter preferred by the Luftwaffe. In short, major compromises in requirements, schedule, or both, appear to be common for most collaborative programs. As a result, disagreements over operational compromises often present major political challenges to collaborative weapons procurement programs.

POLITICAL RECORD

Many of the specific political objectives of collaboration are rarely stated openly. However, it could be argued that it is in the area of political objectives that collaboration has achieved the greatest success. For example, beginning in the 1950s, France sought collaboration with Germany largely to tie Germany to France militarily and to prevent Germany from rebuilding an independent indigenous military industrial base (Nau, 1974). According to Nau (1974, p. 259), "French policy demonstrates a characteristic of dominant partner behavior whose primary interest in cooperation originates from political-strategic motivations." Franco-German collaboration has largely met French objectives, as evidenced by the success of the IEPG and the Kohl-Mitterand proposal for an all-European "Eurocorps" consisting primarily of French and German troops.[18]

Similar objectives have been pursued by the United States vis-à-vis Japan, also with some success. For example, licensed Japanese production of the F-104J and later the F-4 and F-15J solved political problems for the United States and Japan. From the U.S. viewpoint, these programs provided a way for Japan to increase its self-defense capability and shoulder a greater share of the budgetary burden of its

[17]Transall, short for Transport Allianz Working Group, was the consortium formed by the French firm Nord and the German firms Weser and Hamburger.

[18]See, for example, Harris and Steinberg, 1993.

own defense while remaining tied to the United States. From the viewpoint of Japan, licensed production of an American-designed fighter aircraft, within the context of the U.S.–Japan security relationship, was supported by domestic business interests without unduly alarming sensitive regional neighbors.

On the other hand, collaboration programs can have considerable political costs. Among the most significant are disagreements between partners on what to do about programs that are experiencing sharp cost overruns, schedule slippage, or technical failures, or programs for which the military requirements have changed. For example, the U.S.–German codevelopment of a rolling airframe missile (RAM), a type of air-defense anti-anti-ship missile, has created tensions between the two countries. After problematic 1985 tests in which the RAM missed 7 out of 15 firings, the Senate Armed Forces Committee voted against giving the program any more funding. In response, the German defense minister warned that American withdrawal would threaten all future U.S.–German collaborative programs. Similarly, in 1989, the U.S.–Japanese FS-X codevelopment program was almost blocked by the U.S. Congress when critics alleged that the program amounted to a "giveaway" of advanced U.S. aerospace technology.[19] Another example of the difficult political problems and frictions that can arise from collaboration is provided by the U.S.–European AMRAAM/ASRAAM agreement, discussed below.

Case Study 5: The AMRAAM/ASRAAM Agreement Falls Apart

In 1980, the United States, the Federal Republic of Germany, France, and the United Kingdom signed a reciprocal trade agreement on air-to-air missiles following the family-of-weapons concept. Under the terms of the agreement, the United States agreed to develop an advanced medium range air-to-air missile (AMRAAM) while the European consortium would develop its short range counterpart (ASRAAM). Markets for both missiles were guaranteed by each of the participants.

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[19]Lorell, ongoing RAND research.

Initially, the project leader for the European group was Germany. France, who had joined the program with observer status only, pulled out shortly after it began. But the United States soon differed with its European partners over technical goals. In 1982, the United States decreed that the European-designed ASRAAM must fit on unmodified AIM-7 and AIM-9 launch rails. The Europeans responded by offering to develop a missile support unit that would act as an interface between missile and rails. But the support unit design entailed weight growth that was also unacceptable to the United States. After a variety of other problems arose, and several attempts at compromise failed, the Germans left the program in 1988 amidst considerable acrimony.

Following the departure of the Germans, the British agreed to take over management of the European program, making ASRAAM effectively a British program. In the meantime, the American AIM-120 AMRAAM has been developed and deployed and is now selling briskly in third-party markets.

The United States expects to begin testing ASRAAM in early 1995. But it is considered unlikely that the USAF will support procurement of ASRAAM. Over the 15 years in which the ASRAAM program has sputtered, USAF operational requirements have changed. The new AIM-9X, an upgrade of the old AIM-9 Sidewinder, seems likely to fulfill the new USAF requirements better. In the meantime, the British are extremely unhappy at the prospect of no U.S. purchases of the product they so painfully developed.

The British experience with the ASRAAM/AMRAAM reciprocal trade agreement has lent support to those Europeans who openly promote protectionist policies discriminatory against the United States. In response to ASRAAM, as well as to other failed U.S.-European collaboration attempts, some European officials have suggested that future U.S. offers to collaborate with NATO partners will not be taken seriously.[20] Of course, the extent to which the ASRAAM experience has in fact prejudiced European policymakers against American

[20]See for example, statements by the counselor for defense research and engineering, German Embassy, and by the Netherlands state secretary for defense in response to the cancelled Multiple Launch Rocket System codevelopment program involving the United States, United Kingdom, France, and Germany. (Silverberg, 1992.)

equipment or American programs is unclear. Nevertheless, the ASRAAM experience suggests that reciprocal trade arrangements, like other collaboration programs, can be quite susceptible to political controversy.

Chapter Four

IMPLICATIONS FOR U.S. POLICYMAKERS

In considering whether or not to participate in collaborative defense procurement programs, U.S. policymakers must understand and prioritize their objectives. If the economic objectives of rationalization and cost minimization are seen as most important, great care must be taken in structuring programs to minimize inefficient duplication of tasks and excessive bureaucratic oversight. The characteristics of past programs that have succeeded at rationalizing budgets and reducing R&D and procurement costs must be identified and imitated. Since few past programs—particularly those entailing codevelopment—have made resource rationalization their highest priority, however, this may be difficult. One possible model is the civilian Airbus codevelopment program, which specified clear economic criteria for R&D and production work allocations.[1]

If greater equipment rationalization and standardization are sought, the participants' operational requirements for the weapons system must be discussed and harmonized. However, great care must be taken not to negotiate away meaningful national performance requirements and thereby lose the support of the ultimate users of the equipment, the national military services.

Political objectives may be the best reason to seek collaboration. Yet even here, considerable care must be exercised in structuring the

[1]As discussed in Lorell (1980), the 1969 accord between France and Germany specified four criteria for choosing the Airbus engine and other components: (1) the likelihood of development delays; (2) technical merits—performance, endurance, maintenance, and price; (3) airline preferences; and (4) interests of aerospace manufacturers of the participating nations.

program. The long-term negative effects of the bitter disputes with Japan over the FS-X program may eventually counteract any political benefits that could arise from the program. The problems of the U.S. Congress in trying to eliminate the German-American RAM program are also instructive.

The historical record suggests that cooperative production of U.S.-developed systems represents the lowest-risk approach to collaboration from the U.S. perspective. Whereas these types of programs—such as the F-104, F-16, and F-15 licensed-production efforts—often did not lead to realization of the full theoretical benefits of standardization and interoperability that some anticipated, they have generally proven to be cost-effective and beneficial to U.S. industry. However, cooperative production programs based on U.S. systems have become increasingly unacceptable to both first- and second-tier countries. Even countries such as South Korea or Turkey that currently license-produce U.S. fighters are likely to demand a significant role in R&D the next time around.

The troubled history of ASRAAM/AMRAAM also suggests that a full implementation of reciprocal trade arrangements is not forthcoming. As long as the United States seeks to maintain a full-spectrum defense industrial base capability, the sectoral specialization implied by the family-of-weapons concept is unlikely to find great appeal.

In the future, procurement collaboration with major U.S. allies will almost certainly require codevelopment. Small codevelopment programs are easier to manage than large ones but cannot bring the large-scale savings envisioned by the advocates of collaboration. Continuation of collaboration on the scale supported by the Nunn-Warner legislation amounts to little more than political symbolism. Most of these projects can be justifiably characterized as peripheral or marginal, representing only a tiny fraction of U.S. military R&D and procurement expenditures. On the other hand, the efficient and effective codevelopment of major weapons systems is a particularly daunting and challenging prospect, and there still may be useful lessons to be learned from the structure and management of smaller codevelopment programs.

Despite the difficulties facing codevelopment programs, the case study below represents a highly successful cooperative R&D effort

that appears to meet many of the economic, operational, and political objectives outlined above. Perhaps because it is small and is not intended to reach full production, the X-31 codevelopment program has so far managed to avoid most of the problems that have plagued larger, more visible collaborative programs. Nevertheless, we believe it offers valuable insights into the attributes that contribute to successful collaboration.

Case Study 6: Industry Initiative: A Model for Codevelopment?[2]

Development of the X-31 fighter technology demonstrator is a rare example of a successful program—particularly in the area of mutually beneficial sharing of technology and R&D expertise—that is worth reviewing in some detail. It is particularly interesting because it represents the first example of true international codevelopment from the ground up of a military aircraft involving the United States. The X-31 is a fighter-like test aircraft developed to explore the enabling technologies and operational utility of radical improvements in fighter maneuverability. The X-31 is only a technology demonstrator and is not intended for development and series production as an operational weapon system. Nonetheless, the technological and organizational challenges encountered in the design, development, manufacture, and flight testing of the two X-31 prototype aircraft in many respects parallel those encountered in a typical fighter R&D program.

The X-31 aircraft were developed and manufactured collaboratively in the late 1980s by Rockwell International in the United States and by Messerschmidt-Bolkow-Blohm (MBB) in Germany, now part of Deutsche Aerospace (DASA). The program is sponsored and funded by the U.S. Advanced Research Projects Agency (ARPA) and the German Ministry of Defense (MoD). The X-31 has a single government program director—an American—assisted by a deputy who represents the German MoD. The work share is equal to the relative

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[2]This account is based on interviews by Lorell in 1992 of senior industry and government officials involved in the X-31 program. Competent overviews of the program can be found in Lerner (1991), Wanstall and Wilson (1990), and "X-31: The Wonder Plane" (1990).

proportions of funding from the two participating governments. Work tasks were divided up and allocated according to a rational assessment of the technical strengths of the participants.

The X-31 required the design, development, and integration of a variety of advanced technologies and subsystems into a unique aerodynamic configuration that provided highly unorthodox maneuvering capabilities for use during air combat. Program officials and technical experts on both sides of the Atlantic unanimously agree that the R&D program generated a substantial two-way flow of technology and expertise.[3] Yet the R&D program encountered few major problems and virtually no disputes involving technology transfer from either side.

Program officials on both sides agree that the strong perception of mutual technological benefit, particularly on the industry level, was the key to promoting successful technology reciprocity. Both parties brought substantial technical data and R&D experience to the X-31 program from prior national programs that were complementary, and freely shared it. On their own initiative, the two firms undertook collaborative exploratory research from 1981 through 1984, financed with corporate funds. After gaining interest in their novel concepts from elements within the USAF R&D community and elsewhere, the two companies successfully sought funding from their respective governments in 1985 for a joint feasibility study. In June 1986, U.S. and German government officials signed a memorandum of agreement (MoA) for the cooperative funding and development of the X-31.

The remarkably brief and simple MoA calls for "a fair and cooperative research, design, and flight test program of [X-31] technologies." Indeed, the hallmark of the X-31 program was collaboration on virtually all key aspects of the R&D effort, including the maximum feasible sharing of the resulting data within the normal constraints of each country's national disclosure policies. As an example, the primary technical challenge during the initial phase of R&D was development of the basic X-31 configuration. Rockwell and MBB split

[3]Based on multiple interviews in 1991 and 1992 with former X-31 program managers Colonel John Nix (USAF), Lieutenant Colonel Michael Francis (USAF), John Retelle, and James Allburn.

almost equally the total effort that went into configuration development as measured in engineering man-hours. MBB derived the basic wing configuration, but Rockwell developed the detailed shape of the air foil. On the digital fly-by-wire flight control system, the Germans generated the basic control laws, an American subcontractor wrote the code, a U.S. vendor supplied the computer, and Rockwell and MBB integrated and refined the system in close collaboration.

The X-31 program is, of course, not without flaws. The involvement of ARPA, the U.S. Navy, and the National Aeronautics and Space Administration in program management occasionally causes complications. Rockwell compromised on the original airframe design in order to meet some German design objectives. Furthermore, the program's more limited purpose and small scope may have contributed greatly to its success because few critical national economic and political interests are at stake. Nonetheless, its principal attributes—a strong desire to collaborate on the industry level on both sides, a mutually perceived benefit in the sharing of technology and expertise, a rational and sensible division of work tasks based on funding shares, and the technical strengths of each participant—all have contributed to a reasonably cost-effective and successful effort.

Over the years, RAND research on collaborative-development programs has identified a variety of program characteristics that appear to promote better outcomes on large codevelopment efforts. These include

- genuine interest and support from a military service on both sides
- limited objectives, clearly stated and agreed upon by all participants
- similar national performance requirements
- similar national modernization/replacement schedules
- complementary and mutually reenforcing technology, data, or R&D capabilities possessed by the R&D establishments on both sides, and a willingness to share these resources

- industry partners who actively seek collaboration and offer complementary technological strengths and contributions, and who exhibit compatible corporate cultures
- allocation of specific work tasks to take advantage of the relative economic and technological strengths of partners
- avoidance of duplication of tasks in design, development, and production
- a single chain of command with clear lines of authority in program management on both government and industry levels.

Programs that exhibit these characteristics appear to have a greater probability of success in all three categories of security objectives. For example, a program supported by all of the relevant military services will be more likely to meet the operational requirements of those services, and thus is more likely to promote harmonious relations within as well as between participating governments. Likewise, programs in which responsibilities are clearly delineated may be less susceptible to economically and politically costly disputes over program management. Similar national performance and schedule requirements not only encourage standardization and interoperability but make the cost-effective specialization of work tasks possible.

Few of the codevelopment programs examined here have exhibited all or even most of these attributes. Indeed, a skeptic could argue with some justification that no such program is ever likely to exist. Nevertheless, these attributes may be treated as a useful index of the likelihood of success of future codevelopment programs. The more of them that a program exhibits, the greater its chance of success. In order to judge programs effectively, however, U.S. policymakers must still be clear on their own economic, operational, and political objectives for collaboration. Understanding and prioritizing American objectives is a necessary first step before choosing future levels of U.S. participation in collaborative defense-procurement programs.

APPENDIX

Table A.1

Selected Collaborative Aerospace Programs Referenced in Text

Type of Equipment	Program/Type of Collaboration	Countries Involved in Collaboration	Decade Commenced
Fighter/bomber	F-104/coproduction	BE/CA/GE/IT/JA/NL/US	1950s
Fighter	Jaguar/codevelopment	FR/UK	1960s
Patrol	Atlantic/codevelopment	BE/FR/GE/NL	1960s
Transport	Transall/codevelopment	FR/GE	1960s
Fighter	Tornado/codevelopment	GE/IT/UK	1970s
Fighter	Alpha Jet/codevelopment	FR/GE	1970s
Fighter	F-16/coproduction	BE/DK/NL/NO/US	1970s
Missile	Roland/coproduction	FR/GE/US	1970s
Fighter	Eurofighter 2000/codevelopment	GE/IT/SP/UK	1980s
Fighter	FS-X/codevelopment	JA/US	1980s
Fighter	X-31/codevelopment	GE/US	1980s
Missile	AMRAAM-ASRAAM/reciprocal trade	GE/UK/US	1980s
Missile	RAM/codevelopment	GE/US	1980s

NOTE: BE=Belgium, CA=Canada; DK=Denmark, FR=France, GE=Germany, IT=Italy, JA=Japan, NL=Netherlands, NO=Norway, SP=Spain, UK=United Kingdom, US=United States.

BIBLIOGRAPHY

Carlier, C., *Le Développement de L'Aéronautique Française de 1958 à 1970,* Paris: Service Historique de L'Armée de L'Air, 1979.

Chang, Ike Y., *Technology Access from the FS-X Radar Program: Lessons for Technology Transfer and U.S. Acquisition Policy,* Santa Monica, Calif.: RAND, MR-432-AF, 1984.

"Cooperate on Projects," *Defense News,* April 12–18, 1993.

Cothier, P., and A. Moravcsik, "Defense and the Single Market: The Outlook for Collaborative Ventures," *International Defense Review,* September 1991.

Covington, Terrell G., Keith W. Brendley, and Mary E. Chenoweth, *A Review of European Arms Collaboration and Prospects for Its Expansion Under the Independent European Production Group,* Santa Monica, Calif.: RAND, N-2638-ACQ, 1987.

"DOD Inspector General Estimates International Collaboration Savings," *Aerospace Daily,* Vol. 164, No. 35, November 20, 1992, p. 280.

Gansler, J., C. Henning, and J. Serlemitsos, "European Weapons Acquisition Practices: Implications for the U.S.," unpublished manuscript, The Analytic Sciences Corporation, February 1988.

General Accounting Office, *European Initiatives: Implications for U.S. Defense Trade and Cooperation,* Washington, D.C.: GAO/NSIAD-91-167, 1991.

General Accounting Office, *Military Coproduction: U.S. Management of Programs Worldwide,* Washington, D.C.: GAO/NSIAD-89-117, 1989.

Hall, G. R., and R. Johnson, *Aircraft Coproduction and Procurement Strategy,* Santa Monica, Calif.: RAND, R-0450-PR, 1967.

Harris, Scott A., and James B. Steinberg, *European Defense and the Future of Transatlantic Cooperation,* Santa Monica, Calif.: RAND, MR-276-USDP, 1993.

Jane's All The World's Aircraft, London: Jane's Publishing Company Ltd., various issues.

Japan Defense Agency, *Defense of Japan 1990,* translated by the *Japan Times,* 1990.

Kaganoff, Rachel, *Translatlantic Collaboration: Government Policies, Industry Perspectives,* Santa Monica, Calif.: RAND, N-3514-ACQ, 1993.

Kohl, W., *French Nuclear Diplomacy,* Princeton: Princeton University Press, 1971.

Lerner, P., "Stall Tactics," *Air and Space,* April/May, 1991.

Lopez, Virginia C., and Loren Yager, *The U.S. Aerospace Industry and the Trend Toward Internationalization,* Washington, D.C.: The Aerospace Research Center, March 1988.

Lopez, Virginia C., and David H. Vadas, *The U.S. Aerospace Industry in the 1990s: A Global Perspective,* Washington, D.C.: Aerospace Industries Association of America, September 1991.

Lorell, Mark A., *Multinational Development of Large Aircraft: The European Experience,* Santa Monica, Calif.: RAND, R-2596-DRE, 1980.

Nau, H., *National Politics and International Technology,* Baltimore: Johns Hopkins University Press, 1974.

"Perry Vows to 'Resurrect' International Cooperative Programs," *Aerospace Daily,* Vol. 66, No. 4, April 6, 1993, p. 29.

Pinatel, J. B., *L'Economie des Forces,* Paris: Centre d'Etudes Politique des Défenses de l'Université de Paris, 1976.

Reed, A., *F-104 Starfighter,* New York: Charles Scribner's Sons, 1981.

Rich, Michael, William Stanley, John Birkler, and Michael Hesse, *Multinational Coproduction of Military Aerospace Systems,* Santa Monica, Calif.: RAND, R-2861-AF, 1981.

Silverberg, D., "Luster Fades Over Cooperative Programs," *Defense News,* January 27, 1992.

Steinberg, James B., *The Transformation of the European Defense Industry: Emerging Trends and Prospects for Future U.S.–European Competition and Collaboration,* Santa Monica, Calif.: RAND, R-4141-ACQ, 1992.

Wanstall, B., and J. R. Wilson, "Air Combat Beyond the Stall," *Interavia,* May 1990.

Webb, Simon, *NATO and 1992: Defense Acquisition and Free Markets,* Santa Monica, Calif.: RAND, R-3758-FF, 1989.

"X-31: The Wonder Plane," *Asian Defence Journal,* June 1990, pp. 80–83.